Space Weather Technical Forecast

Issued on Wednesday, 24 January 2024 at 00:50 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

---

Space Weather Forecast Headline: CME arrivals possible later 25 January into early 26 January, with G1/G2 storming likely. Moderate solar activity likely.

Analysis of Space Weather Activity over past 24 hours
Solar Activity: Solar activity has been Moderate with multiple M-class flares observed from AR3559 nearing north centre disc and AR3561 in the southwest. The peak flare of the last 24 hours, M5.1 at 23/0331UTC, was from AR3559. AR3559 is a long region with a fairly large delta spot in the middle, although this maybe starting to break apart. AR3561 is the most complex region, with multiple mainly small spots which keep changing in configuration, but including several delta spots. In addition, it is in close proximity to AR3555. AR3555 has developed a trailer which is a delta spot in its own right, although arguably it could now be considered one region with AR3561. The remaining regions appear simpler at this time.
There have been several CMEs emerge in the last 24 hours, some of which have the potential to glance Earth in the coming days. Analysis is still underway, but the most likely time for CME impacts is 25 into 26 January.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by ACE and DSCOVR, have been at mostly slightly elevated levels with weak CME effects. Wind speeds varied between 360-450 km/s. Density has been average or below. Total magnetic field strength has been weak to moderate at 8nT or below. Bz has varied mostly weakly, between +/- 7nT. Phi angle was mainly positive (away from the Sun), with some recent variations. Geomagnetic activity has been Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux was slightly above normal background levels at first, but declined to background over the 24 hour period.
GOES16 high energy (greater than 2MeV) electron flux was at background levels. The associated 24-hour fluence was well below the Active (1e8 integrated pfu) threshold on a steady trend. At 24/0000UTC the 24-hour integrated fluence observation was 1.35e6 integrated pfu.

Four-Day Space Weather Forecast Summary
Solar Activity: M-class flares are likely throughout from AR3561 and the AR3559, with a slight chance of X-class flares.

Solar Wind / Geomagnetic Activity: There is potential for at least three CME glancing blows in the coming days. In addition, these CMEs are all expected at a similar time - from later on Day 2 (25 Jan) to early on Day 3 (26 Jan), with the possibility that they either combine or arrive one after the other, perhaps increasing any geomagnetic effects.
Overall, geomagnetic activity is expected to be Quiet to Unsettled on Day 1 (24 Jan). An increase is expected on Day 2 into Day 3, perhaps step-wise if the various CMEs arrive separately, with G1-G2/Minor-Moderate Storms likely and a slight chance of G3/Strong Storms, should the CMEs combine favourably for this to occur.

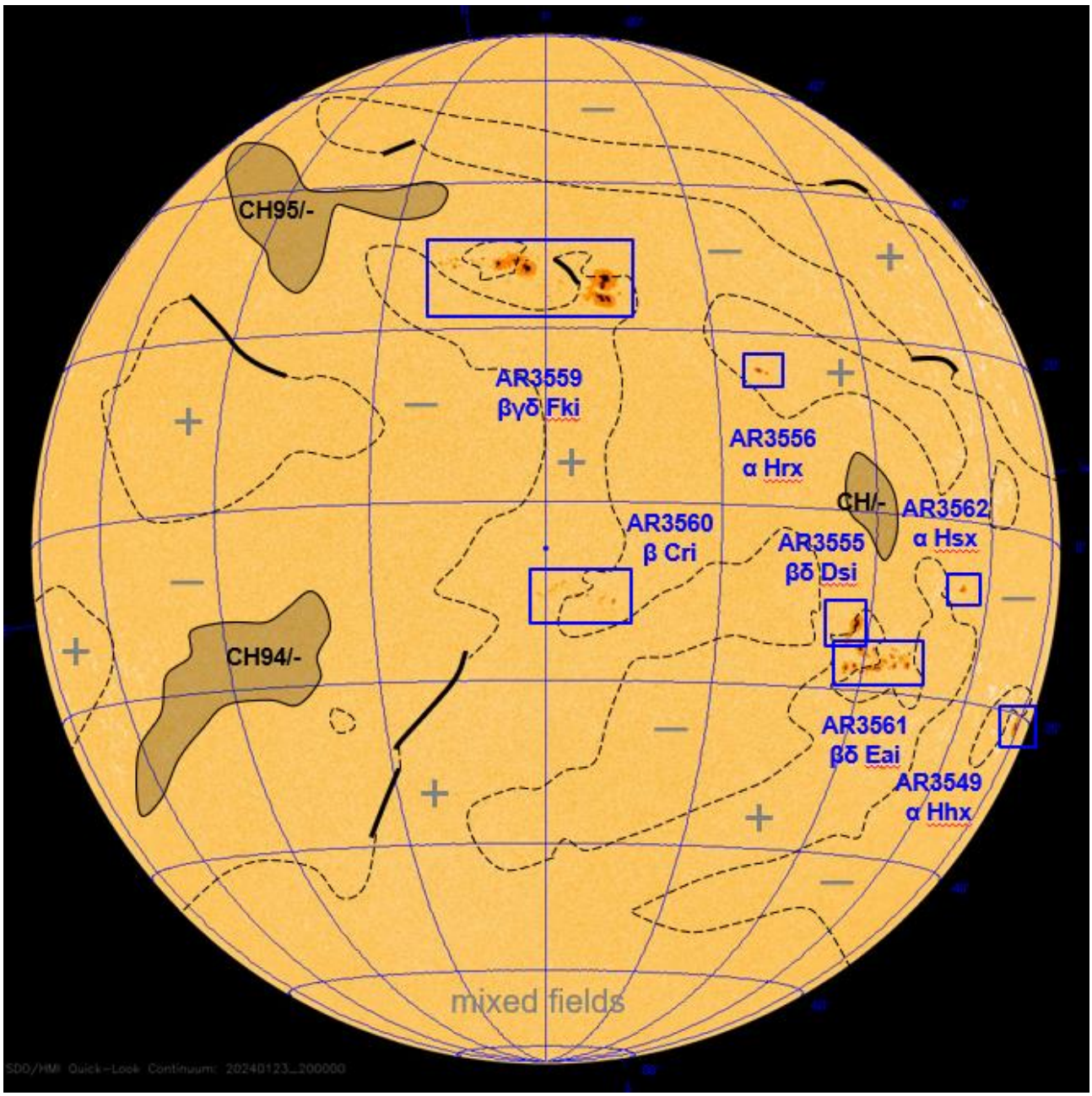
Energetic Particles / Solar Radiation: There is a slight chance of radiation storms throughout,

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

due to the magnetic complexity and flare history of both AR3559 and AR3561.
The high energy electron (greater than 2MeV) flux is uncertain due to the effects of multiple CME arrivals on the forecast, but may rise towards the end of the period. There is a slight chance of electron fluence exceeding Active (1e8 integrated pfu) by the end of Day 4 (27 Jan), but with significant uncertainty.

Figure 1. Solar Analysis Valid 23/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Met Office Space Weather Technical Forecast

Geomagnetic Storms:

There have been numerous CMEs seen in coronagraph imagery over the last couple of days. The majority of these have been either northward or southward directed, but there is potential for several glancing blows in the coming days. Of these, there are two CMEs which emerged on 22 and 23 January which are mostly directed below Earth's orbit, but are likely to give some impact at Earth. A third, also seen on 23 January, has the material of the CME directed well to the north of Earth, but a wider shock signature was visible in coronagraph imagery and this may also give a glancing blow.

In addition, these CMEs are all expected at a similar time - from later on Day 2 (25 Jan) to early on Day 3 (26 Jan), with the potential for them to either combine or arrive one after the other, perhaps increasing any geomagnetic effects.
A weak coronal hole has been identified in centre disc, but this is unlikely to enhance the solar wind significantly.

Overall, geomagnetic activity is expected to be mostly Quiet to Unsettled on Day 1 (24 Jan). An increase is expected later Day 2 into Day 3, perhaps step-wise if the various CMEs arrive separately, with G1-G2/Minor-Moderate Storms likely and a slight chance of G3/Strong Storms, should the CMEs combine favourably for this to occur.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	50	70	10
Strong	G3	No	1	5	15	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

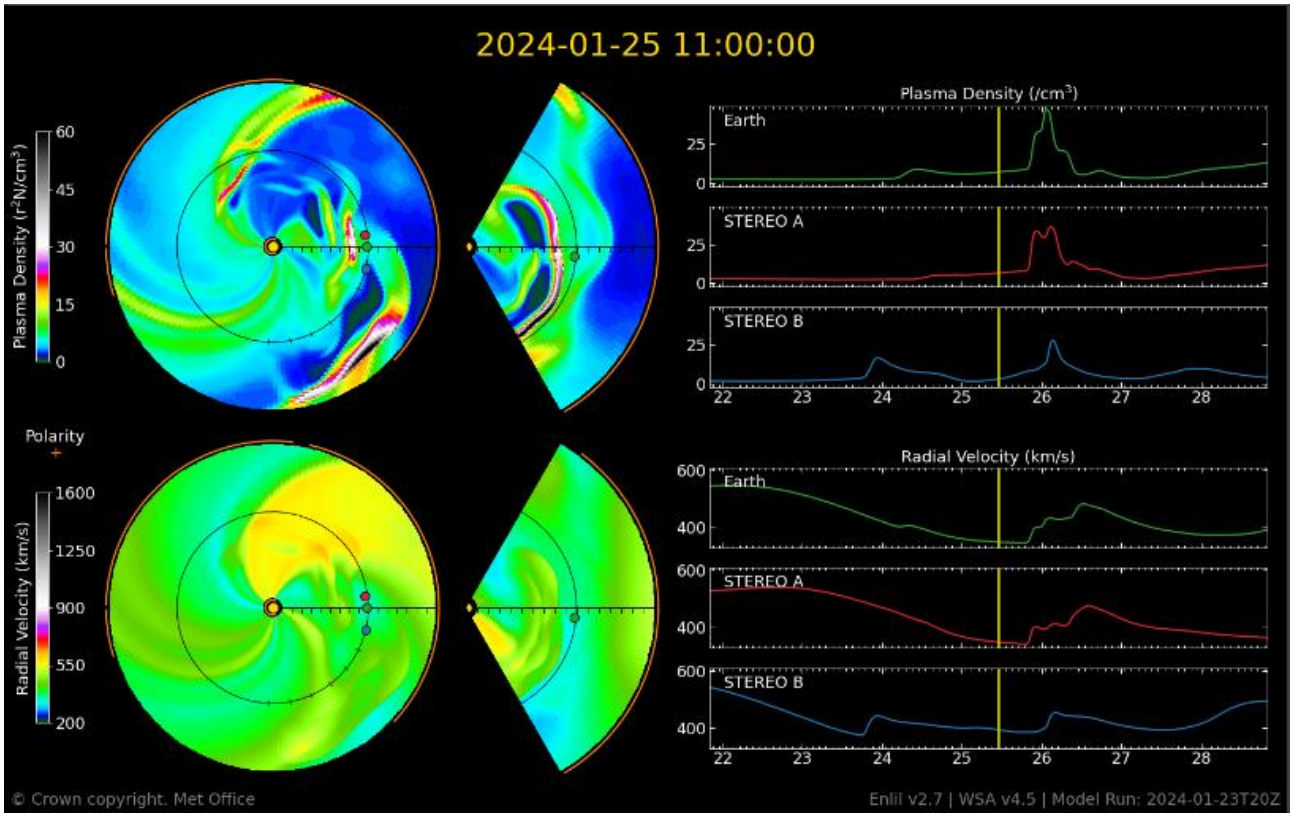
Geomagnetic Activity - Earthbound Coronal Mass Ejections

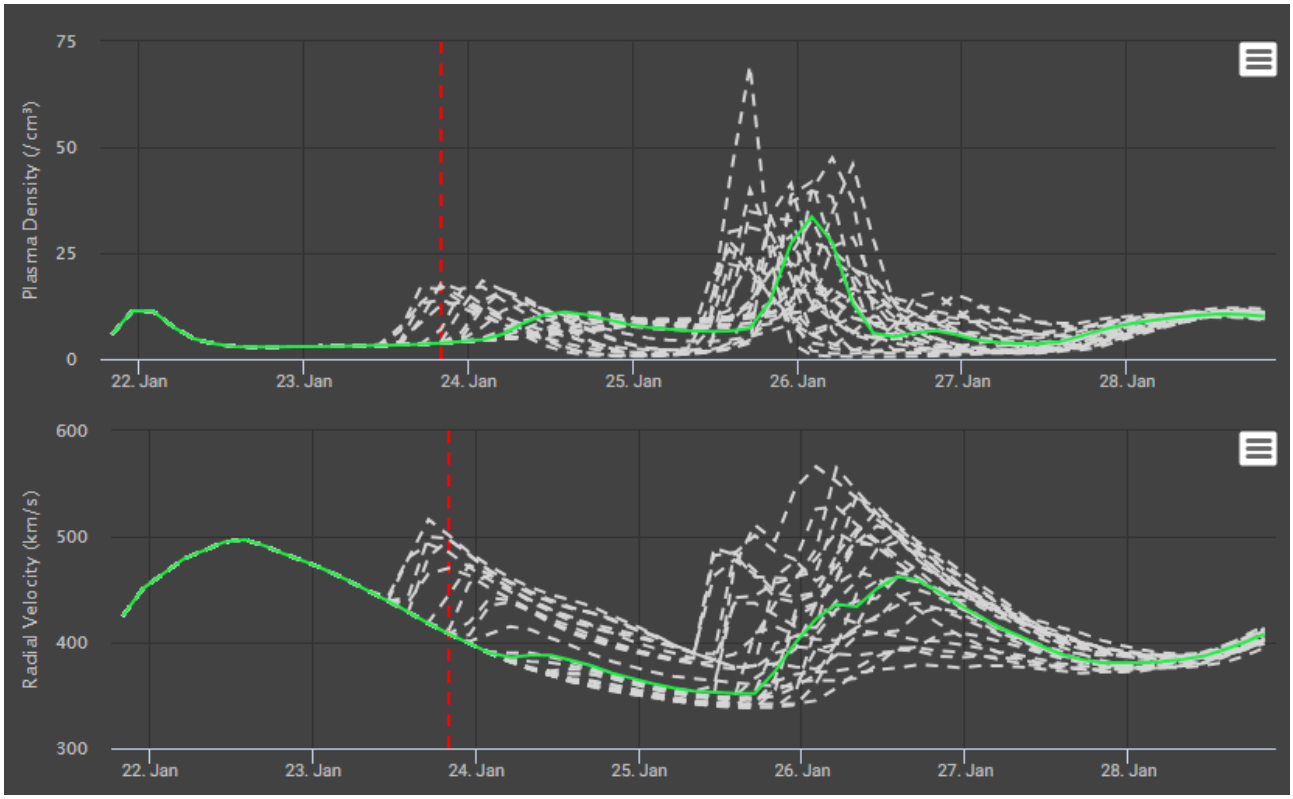
Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
22/1559	Partial	Filament	South-centre disc	620 km/s	25/2100 UTC	Glancing blow
23/0700	Partial	AR3559	Northeast	840 km/s	26/0000 UTC	Mostly shock
23/1230	Partial	AR3561	Southwest	650 km/s	26/0600 UTC	Glancing blow

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Figure 2: MOSWOC Enlil and ensemble, showing the most likely arrival time for CMEs is in the period later 25 January through early 26 January.





Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

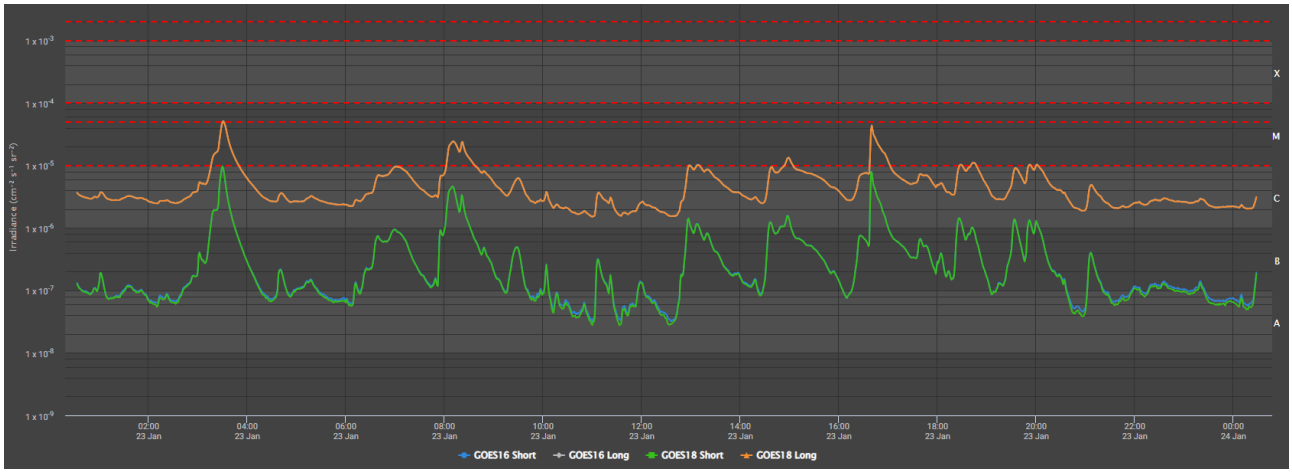
Radio Blackouts - X-Ray Flares:
Solar activity has been Moderate, with numerous M-class flares from AR3559 and AR3561, peaking with M5.1 at 23/0331UTC from AR3559.

There are seven sunspots on the visible disc. AR3559 (Fki/Beta-Gamma-Delta) is a long region with a fairly large delta spot in the middle, although this may be starting to break apart. AR3561 (Eac/Beta-Delta) is the most complex region, with multiple mainly small spots which keep changing in configuration, but including several delta spots. In addition, it is in close proximity to AR3555. AR3555 has developed a a trailer which is a delta spot in its own right, although arguably it could now be considered one region with AR3561. The remaining regions appear simpler at this time.

AR3561 and AR3555 are both due to rotate off the disc during Day 4 (27 Jan), but any downturn in flare risk from losing this region will not be until after the end of this period, assuming no change in configuration. With no significant regions expected to rotate on in the coming days, flare risk has been kept flat during this period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	70	70
Very Active	R3 to R5 X Class	No	15	15	15	15

Figure 3: GOES16 and 18 x-ray flare trace, showing several M-flares in the last 24 hours.



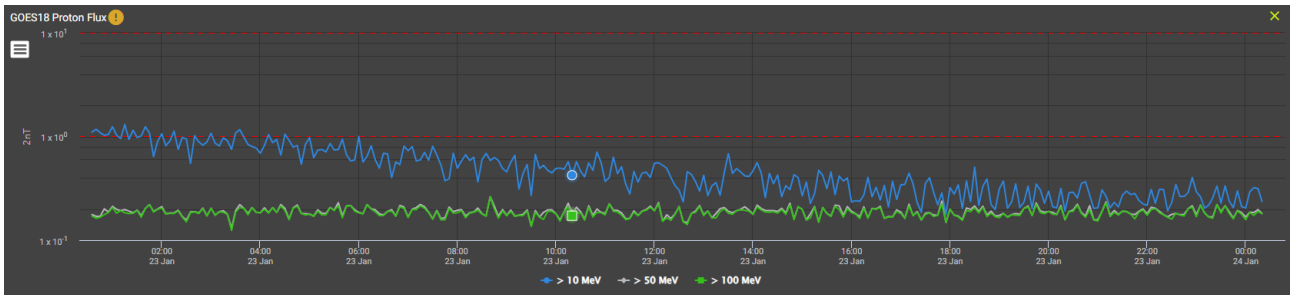
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):
GOES18 high energy (greater than 10MeV) proton flux has returned to background levels. There is a slight chance of radiation storms throughout, due to both AR3561 in the western hemisphere and AR3559 now approaching the western hemisphere. Both of these regions are magnetically complex.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	20	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES18 proton flux, showing a decline to background levels following an increase on 22 January, likely due to a CME arrival.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

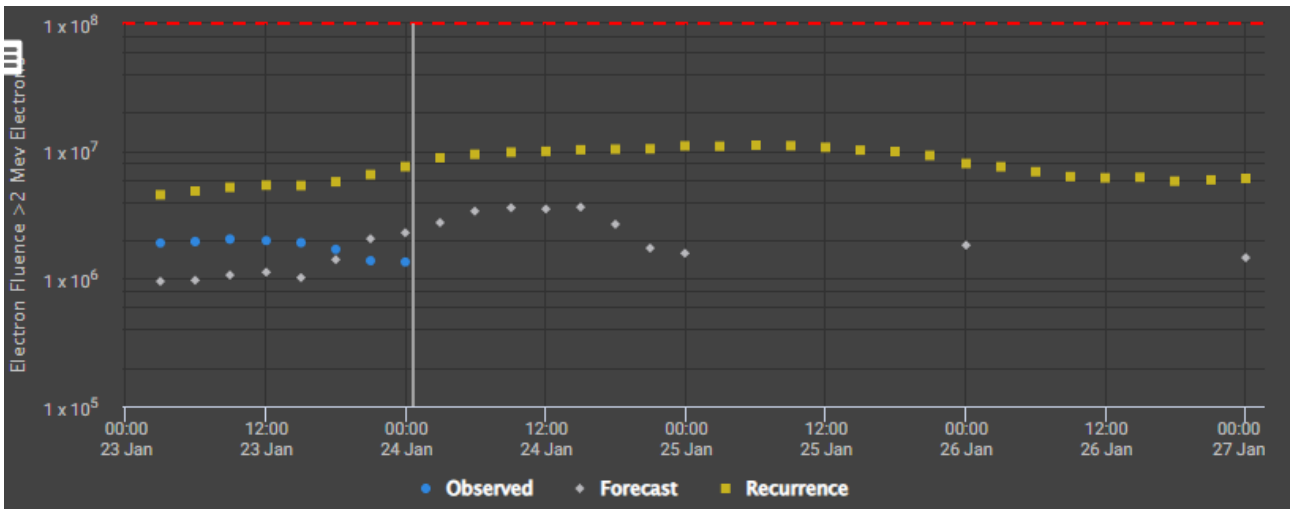
© Crown Copyright 2024. All Rights Reserved.

High Energy Electrons Event (≥ 2MeV):
The high energy electron (greater than 2MeV) flux is uncertain due to the effects of multiple possible CME glancing blows on the forecast, but will most likely remain at background levels for much of this period. Towards the end of the period, as CME effects are starting to wane, then electron flux may start to rise. This will be especially true if the CME arrival(s) give stronger geomagnetic activity. However, this is also assuming no further Earth directed CMEs emerge, and at present further CMEs are considered a likely scenario.

Electron fluence is likely to stay below Active (1e8 integrated pfu) for much of this period, but there is potential for a rise later Day 3 into Day 4 (26-27 Jan). Whilst REFM is currently reflecting this forecast as it only goes out three days, it will not be taking into account any potential CME impact, and will become increasingly unreliable in the coming days.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	1	5	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: MOSWOC REFM showing a steady below Active trend in the next three days. This won't be taking account of upcoming CME arrivals.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.